

# Proprioceptive Neuromuscular Facilitation Techniques in Sports Medicine: A Reassessment

Paul R. Surburg, PhD, RPT; John W. Schrader, HSD, ATC

**Objective:** The purpose of this survey was for comparison with a similar 1981 survey to determine if proprioceptive neuromuscular facilitation (PNF) techniques are being implemented in the same manner today.

**Design and Setting:** The survey was made available at the 1993 NATA Clinical Symposium.

**Subjects:** The subjects were 131 athletic trainers representing all major national athletic conferences who attended the 1993 NATA Clinical Symposium and who stated that they used PNF exercise in their practice.

**Measurements:** The survey consisted of 15 questions dealing with academic preparation, years of practice, scope and method of preparation in PNF, application of nine PNF techniques to various joints and regions of the body, and the most successful use of PNF techniques.

**Results:** PNF techniques are most frequently applied during rehabilitation of the knee, shoulder, and hip, similar to 1981

except that the use of these techniques during ankle rehabilitation has increased. In both studies, the most frequently used techniques were contract-relax and hold-relax. Two techniques not surveyed in 1981, contract-relax-contrast and hold-relax-contrast, are becoming techniques of choice for elbow, wrist, hip, and knee rehabilitation. The use of PNF techniques in the muscle re-education phase of rehabilitation is an application identified in this survey not cited by athletic trainers in the 1981 survey.

**Conclusions:** Proprioceptive and kinesthetic deficits are known to occur after certain types of injuries, and the use of PNF techniques to correct these problems is a natural application. A contemporary trend in exercise rehabilitation is multi-planar exercises, which are typified by PNF techniques.

**Key words:** proprioception, neuromuscular, facilitation, injuries

How do athletic trainers use proprioceptive neuromuscular facilitation (PNF)? More specifically, what PNF techniques have athletic trainers found to be effective in treating injuries in specific areas of the body? The response to this question will vary in context and scope.

Several reasons for response variability will be briefly examined in this introductory section. In accredited athletic training programs, undergraduate athletic training students are exposed to PNF. Students are expected to understand the underlying principles of this system and glean concepts related to application. The scope of coverage is predicated upon the preparation and practical experience of the instructor in PNF. Thus, the reply to the question regarding application of PNF techniques may be brief and vague for some athletic trainers. The information in this study should expand knowledge of PNF applications and possibly provide new insights for effective use and variations.

A brief review of the literature on PNF techniques and their applications is provided in the following paragraph. While these studies provide some guidance for PNF application, one must be aware that the majority of these studies involve subjects with no type of athletic injury. By contrast, the responses of athletic trainers in this study relate to treating injured athletes.

Numerous investigations establish PNF techniques as more efficacious treatments than traditional static stretching exer-

cises for range of motion or flexibility enhancement.<sup>1-3</sup> Treatment modalities used with PNF techniques have been examined to ascertain the relative merits of combination treatments. Results of studies applying cryotherapy with PNF are mixed in nature.<sup>4,5</sup> Using the Hoffman reflex to assess motor unit recruitment, results show that PNF techniques produce a strong but brief neuromuscular inhibition.<sup>6</sup> While investigating the role of PNF techniques for flexibility development, a physical therapist reported a significant increase in hamstring flexibility of the contralateral, nonexercised leg with the contract-relax technique. This transfer effect provides additional evidence of neurological mechanisms operating with PNF applications.<sup>2</sup> A study by Hardy<sup>1</sup> provides insights into certain applications and modifications of PNF techniques. He examined duration of isometric contractions and found 6 seconds to be the ideal length of contraction time for the hold-relax technique. Another finding is that this hold-relax procedure may be more effective when an isotonic contraction of the hip flexors follows the isometric contraction of the hip extensors. This modification, called hold-relax-contrast, was incorporated into our study.

There is a paucity of data about the application of PNF for injured athletes at the high school and college levels. While athletic trainers should be cognizant of data-based, quasi-experimental studies,<sup>7-9</sup> it is important for them to gain insights into PNF practices implemented by their peers, thereby adding to a valuable body of knowledge in the area of rehabilitation. In essence, this survey represents the "best practice" in over 131 case studies.

Paul R. Surburg is a professor and John W. Schrader is coordinator of the athletic training program in the Department of Kinesiology, Indiana University, Bloomington, IN 47405.

Over a 13-year period, aspects of therapeutic exercise or protocols have changed in emphasis, role, and importance. Isokinetic exercises were the exercise of choice 13 years ago for various aspects of the rehabilitation process and considered "cutting edge" protocols. While isokinetic exercises are still important in rehabilitation, closed kinetic chain exercises are considered vital in many contemporary therapeutic protocols. Along with changes in priority and usage among types of exercises, there may also be application changes within a therapeutic regimen. Are certain PNF techniques being used more frequently or differently in contemporary rehabilitation programs than in 1981? The purpose of this study was to compare this survey with a 1981 study<sup>10</sup> to determine if PNF techniques are being implemented in the same manner as 13 years ago.

## METHODS

One hundred and thirty-one athletic trainers participated in this study and represented all major athletic conferences in the United States. The survey instrument was made available at the 1993 National Athletic Trainers' Clinical Symposium. Survey instruments were available on a table in the registration area. Potentially all registered athletic trainers, approximately 8,000, could have participated. Participants were asked to complete this survey only if they used some type of PNF exercise. As with the 1981 study, athletic trainers were selected because they either inaugurate and supervise the use of PNF techniques or administer these exercises based upon a physician's recommendation.

The foundation of this therapeutic system is predicated upon the involvement of four neurophysiological mechanisms: reflexes, resistance, irradiation, and successive induction. Irradiation is the "spread of excitation in the central nervous system which causes contraction of synergistic muscles in a specific pattern."<sup>11</sup> Successive induction refers to contraction of an agonist muscle group followed by activation of the antagonist muscle group.

A key component in PNF is the execution of movement in diagonal, spiral patterns.<sup>12-14</sup> Some of the PNF techniques discussed in succeeding paragraphs are executed in the cardinal planes rather than diagonal, spiral patterns. These modifications of PNF techniques will be designated as Facilitation Patterns. Diagonal patterns accompanied by resistance are intended to elicit irradiation and muscle recruitment. Detailed explanations of PNF may be found in various publications.<sup>13-15</sup>

Nine different PNF techniques were surveyed in this study. Seven were included in the 1981 study and were based upon the work of Kabat<sup>11</sup> and Knott and Voss<sup>12</sup>: repeated-contraction, rhythmic-initiation, slow-reversal, slow-reversal-hold, rhythmic-stabilization, contract-relax, and hold-relax. Two additional techniques included in this study, contract-relax-contract and hold-relax-contract, were based upon the work of Hardy<sup>1</sup> and represent modifications of hold-relax and contract-relax techniques. Respondents identified use of these techniques for the following joints: neck, shoulder, elbow/wrist, fingers, back, hip, knee, and ankle.

As with the 1981 study, an open-ended question was included in the survey. Athletic trainers were asked to describe their most successful use of PNF techniques. Ninety-two (70%) individuals provided additional insights into PNF or Facilitation Patterns use through this question. The frequency and nature of the responses in this portion of the survey were similar to and seem to validate the responses of the multiple choice portion of this instrument. While frequency of use for the nine techniques is not synonymous with technique efficacy, it would seem evident that the pragmatic athletic trainer would discontinue application unless satisfactory results are obtained.

The instrument consisted of 15 questions. Questions 1 through 4 dealt with academic preparation, years of practice, and scope and method of preparation in PNF. The next 7 questions dealt with the application of the nine PNF techniques to various joints and regions of the body. Following the open-ended question, all nine PNF techniques were succinctly described. The first few sentences in each succeeding paragraph are a paraphrase of the technique description.

## Repeated-Contraction

This technique involves executing diagonal, spiral-patterned movements against resistance several times through a full range of motion. The athletic trainer selects the diagonal pattern that will enhance the strength or movement of a targeted muscle or muscle group. A vital element in PNF is the diagonal spiral pattern, which serves as a basis of movement for the various techniques. These diagonal patterns with a rotary component involve movements in three dimensions with sequential, and at times, simultaneous movement at several joints. Motions are initiated distally and proceed proximally. Patterns are named according to their finished position. For each direction there are two basic patterns (Fig 1). For the shoulder the motions are flexion-adduction-external rotation, also referred to as D1, and flexion-abduction-external rotation, also referred to as D2. Reciprocal or antagonist patterns are implemented with certain PNF techniques. Extension-abduction-internal rotation and extension-adduction-internal rotation are the reciprocal shoulder patterns. One could substitute hip for shoulder and repeat the pattern sequences for D1 and for D2; the rotation motion would change from external to internal rotation or vice versa for the D2 sequences.

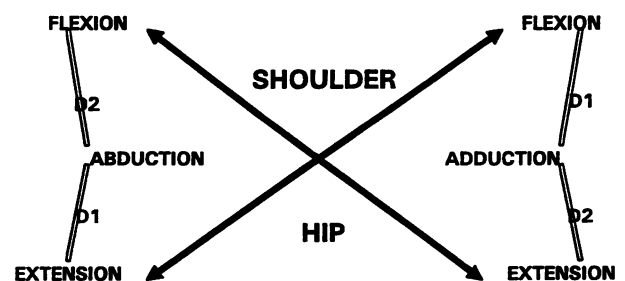


Fig 1. The PNF technique of repeated contraction involves executing diagonal, spiral-patterned movements against resistance several times through a full range of motion. Shown here are the two basic patterns for the shoulder and hip.

## Rhythmic-Initiation

An athletic trainer passively ranges the athlete through a diagonal spiral pattern of motion. As the athlete relaxes, the athletic trainer asks the athlete to assist the movements. Movements are repeated with gradual resistance applied by the trainer to the diagonal spiral movements. This is a four-stage progression involving passive, active assistive, active, and resistive movements. These movements may be executed in agonistic or antagonistic patterns. The final stage of rhythmic-initiation is essentially the repeated contraction technique. Voss et al<sup>14</sup> state that "this technique involves voluntary relaxation, passive movement, and repeated isotonic contractions of the major muscle components of the agonistic pattern." The following five techniques (No. 3-No. 7) closely follow PNF techniques as developed by Kabat.<sup>11</sup>

## Slow-Reversal

Maximum resistance is applied to an isotonic contraction of the antagonistic pattern; this is immediately followed by an isotonic pattern of the agonistic muscles. Benefits ascribed to this technique are strength development of antagonistic muscle groups, improved action of agonistic muscles, and facilitation of reversal muscular action.

## Slow-Reversal-Hold

This technique is identical to slow-reversal except at the termination of each pattern sufficient resistance is applied to cause an isometric contraction. This technique may be performed through a full or partial range of motion. Some athletic trainers believe this technique may be used to develop strength at specific points in a range of motion.<sup>16</sup>

## Rhythmic-Stabilization

The athletic trainer applies resistance to cause an isometric contraction of the agonistic muscle pattern. This contraction is followed immediately by an isometric contraction of the antagonistic muscle group. This technique may be done in a diagonal spiral pattern (PNF) or in the cardinal planes (Facilitation Patterns). The latter approach is found in Cailliet's<sup>17,18</sup> work. He maintains that this technique increases strength, improves local blood supply, and increases range of motion.

## Contract-Relax

An athletic trainer passively moves an extremity through an agonistic pattern until resistance is felt. At this point the athlete is told to isotonically contract the antagonistic muscle groups in a diagonal spiral pattern as the therapist provides resistance to these movements. Voss et al<sup>14</sup> maintain that the resistance provided by the therapist should allow the athlete some rotatory movement but should prevent movement of the other components of the pattern. Following this contraction the athlete is told to relax, and after a brief interval the therapist passively moves the extremity again into the agonistic pattern.

To enhance flexibility or range of motion, a Facilitation Pattern of this technique might be implemented. For increasing hamstring flexibility, the athletic trainer would passively flex the leg at the hip with the knee in extension. When the hamstrings are in an elongated position with sufficient resistance to additional hip flexion, the athlete is told to isotonically extend at the hip as the athletic trainer applies resistance to this motion in the sagittal plane. After the leg is back to the original or resting position and the athlete has been told to relax the leg muscles, the athletic trainer will again passively flex the leg at the hip joint. The initiation of this passive motion denotes the inauguration of a second repetition. Enhancement of limited range of motion is often cited as the rationale for utilizing this technique.<sup>14,16</sup>

## Hold-Relax

This technique is very similar to contract-relax except that the antagonistic muscle pattern with all components, including rotation, is resisted sufficiently to cause an isometric rather than an isotonic contraction. All other facets of this technique are identical to contract-relax. If a Facilitation Pattern modification of this technique is implemented, motions and isometric contractions take place in a cardinal plane; for the hamstrings, the sagittal plane would be used.

## Contract-Relax-Contract

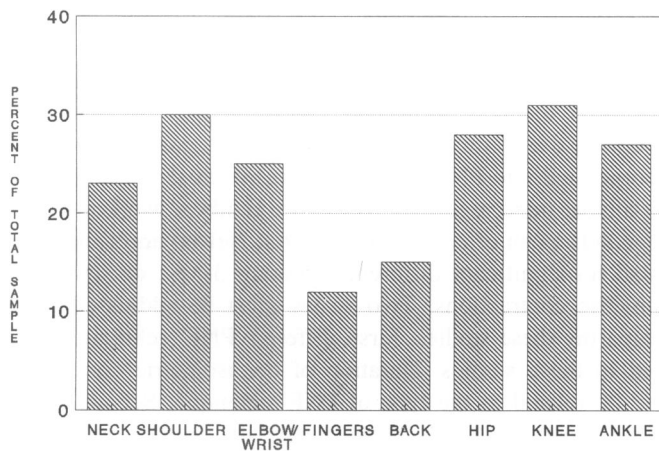
The athletic trainer passively moves the extremity until resistance is felt. At this point the athlete is told to isotonically contract the antagonistic muscle groups. This is followed by an isotonic contraction against resistance of the agonistic muscles. Following this contraction the athlete is told to relax all muscles and the initial starting position is established. This procedure may be repeated several times in a treatment session. Contract-relax-contract is a technique not included in the 1981 study. Hardy<sup>1</sup> described it as an "active" technique. The isotonic contraction of the agonistic muscle groups at the culmination of this pattern is this "active phase." Using Hardy's nomenclature, hold-relax and contract-relax techniques would be ascribed a "passive" designation.

## Hold-Relax-Contract

This technique is similar to the contract-relax-contract with the only alteration being an isometric contraction of the antagonistic muscles rather than an isotonic contraction. There is evidence to substantiate the efficacy of this technique over the older hold-relax technique.<sup>7</sup>

## RESULTS

The survey instrument was designed to ascertain which PNF or Facilitation Patterns techniques were used at various joints of the body (Fig 2). Proprioceptive neuromuscular facilitation techniques were used most frequently for injuries to the knee (31%), shoulder (30%), hip (28%), ankle (27%), elbow/wrist (25%), neck (23%), back (15%), and fingers (12%).

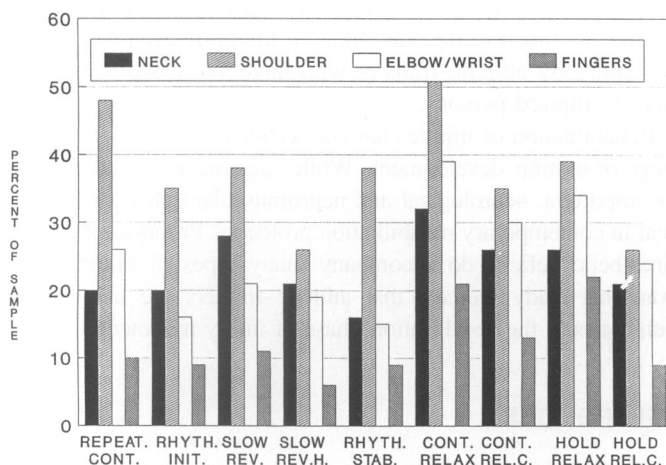


**Fig 2. PNF techniques were used most frequently for injuries to the knee, shoulder, hip, ankle, elbow/wrist, and neck.**

### Neck and Upper Extremity Usage

Figure 3 shows the usage of the nine techniques for neck and upper extremity treatments. Contract-relax, the technique used most frequently with the neck, involves passive motion in one direction followed by resisted motion in the antagonistic pattern. Slow-reversal was opted as the second most frequently used technique. An area of commonality among these procedures is neck motion in one direction followed by movement in the opposite direction. Slow-reversal, however, initially involves movement by the antagonistic muscle groups, and contract-relax is begun with passive motion of the agonist muscles. A finding of this study was the decline in use of rhythmic stabilization for neck conditions.

The three most frequently applied techniques for shoulder rehabilitation are contract-relax, repeated-contraction, and hold-relax. Use of the latter two techniques has reversed since 1981. Repeated contractions are cited as rehabilitation protocol for "throwing shoulder and shoulder strains." One respondent elaborates upon the implementation of repeated contractions, and emphasizes the use of spiral patterns along with rotation, flexion/extension, and abduction/adduction.



**Fig 3. Contract-relax and slow reversal were the PNF techniques used most frequently for injuries to the neck, while contract-relax, repeated contraction, and hold-relax were used most often for injuries to the shoulder.**

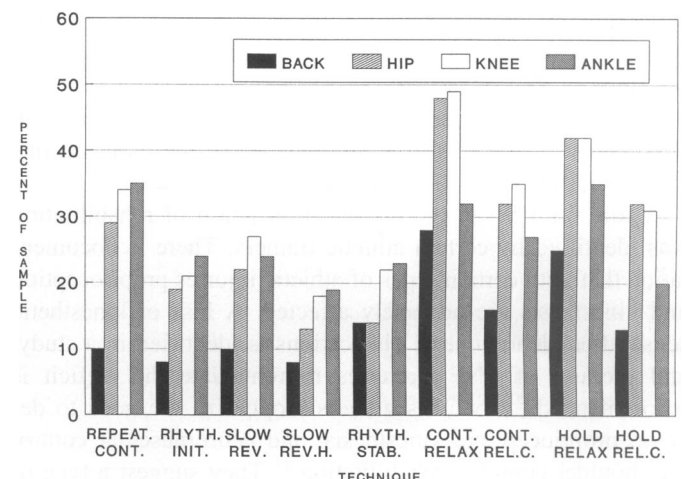
For the elbow/wrist areas, contract-relax, hold-relax, and contract-relax-contraction were the three most frequently used techniques. In the 1981 study repeated-contraction was the second most frequently applied technique.

### Back and Lower Extremity Injuries

As with the 1981 study, contract-relax and hold-relax were the techniques of choice for the hip region. In the open-ended question these techniques are often cited as successful rehabilitation procedures for hamstring problems. The sequencing of hold-relax followed by contract-relax was noted by several persons. As one peruses Figure 4, one sees that the hip designation could cover injuries to abductors, adductors, and the quadriceps.

Technique use at the knee parallels usage at the hip. The biarticular nature of certain muscle groups would again account for some of this duplication of the two most frequently selected techniques. Rhythmic-stabilization is not selected very frequently by respondents but is mentioned by several athletic trainers in the open-ended question. While the specificity of the injury was not delineated, motionless exercises have been suggested in managing chondromalacia patella. Hold-relax-contraction was selected by one person to treat patella tendinitis. This technique and contract-relax-contraction were being extensively used for hip and knee problems.

Inspection of Figure 4 reveals that, as one descends the joints of the lower extremity, repeated-contraction becomes more frequently applied in rehabilitation situations. This same observation may be applied to rhythmic-initiation. Several participants cited the latter technique as the one found to provide the most success in treating ankle injuries. One athletic trainer stated, "[For] lateral ankle sprain I like to use slow reversal to maintain and gain strength." While not for exclusive use at the ankle, another trainer commented, "I have had success using PNF patterns in the swimming pool for both upper extremity and lower extremity muscular problems." Again, a more generic application was provided by another respondent: "The type I use most depends: for a very acute or



**Fig 4. For injuries to the back and lower extremities, the use of repeated contraction and rhythmic initiation increased.**

painful athletic injury I will use hold-relax. For stretching I use contract-relax or slow-reversal and for re-education I use repeated-contraction."

## DISCUSSION

A comparison of PNF use for various joints of the body revealed similar trends between this study and the 1981 publication. In both studies knee, hip, and shoulder joints were the most frequently treated with PNF techniques.

The most radical departure in usage between the two studies is the ankle, which in our study replaces the neck among the top four joints. In the 1981 study, rhythmic stabilization was implemented more extensively than slow-reversal and contract-relax. Rhythmic stabilization has been recommended as a mobilizing technique,<sup>17,18</sup> and as a means to gain relaxation,<sup>11</sup> increase strength,<sup>15</sup> and enhance circulation.<sup>12</sup> An athletic trainer notes, for throwing injuries, the use of repeated contractions with flexion/extension, abduction/adduction, and rotation incorporated into spiral patterns. A study by Blakely and Palmer<sup>19</sup> found with flexion, adduction, and external rotation pattern of the shoulder, lateral or external rotation occurred during the first phase of this pattern and medial rotation was evident during the last phase of this spiral pattern. This finding should be considered when selecting patterns for shoulder rehabilitation.

Contract-relax, hold-relax, and contract-relax-contrast were the three most frequently used techniques for the elbow/wrist areas. The second most frequently applied technique in the 1981 study was repeated-contraction. Contract-relax-contrast technique was not included in that survey. While repeated-contraction and this technique are both isotonic in nature, contract-relax-contrast involves motion of both antagonistic and agonistic muscle groups. This reciprocity of motion may enhance the rehabilitation process for these joints, because successive induction is a basic tenet of PNF.

For lower extremity rehabilitation, two techniques (contract-relax-contrast and hold-relax-contrast) are being applied more frequently than four of the original techniques.<sup>11</sup> While these two techniques were not included in the 1981 instrument, the open-ended part of the 1981 survey did not elicit responses about utilizing these techniques. In a relatively short period of time these techniques are becoming standard protocols for certain treatment situations.

In 1981, PNF exercises were being used as warm-up procedures. While this may continue to be the case, no one mentioned this usage in the present survey.

A role for PNF in the re-education phase of rehabilitation was identified by certain athletic trainers. There is documentation that with certain types of athletic injuries proprioception and kinesthesia are adversely affected. A loss of kinesthetic sense after glenohumeral dislocations is identified in a study, and the use of PNF exercises to remediate this deficit is recommended.<sup>20</sup> Two researchers emphasize the need to develop proprioception, kinesthesia, and neuromuscular control for shoulder complex rehabilitation.<sup>21</sup> They suggest a type of plyometric training utilizing D2 movements. Additional clinical and laboratory investigations are needed to ascertain how

the standard PNF techniques and elements of the therapeutic approach devised by these investigators may be used to enhance kinesthesia and neuromuscular control.

In like manner, additional investigations are needed to determine the optimal duration of isometrics contraction (hold) incorporated into PNF techniques. At the present time there is not a clear trend regarding this issue. Hardy's<sup>1</sup> work indicates 6 seconds as an effective duration, but Nelson and Cornelius<sup>7</sup> found no significant differences among 3-, 6-, or 10-second isometric contractions. Two issues must be addressed when comparing these studies. First, different PNF techniques were used in these studies. Duration of the isometric contraction may be related to the type of PNF technique. Second, while Hardy found 6 seconds to be statistically significant, Nelson and Cornelius did not find any significant differences. One must be cautious about trying to prove a point by retaining the null hypothesis. In the present survey, no input was received about optimal duration of isometric contraction associated with the hold aspect of a technique. Four of the surveyed techniques did involve an isometric contraction in some aspect of the technique.

Respondents in certain cases did designate a type of athlete for whom a PNF technique was most effective. Repeated-contraction was cited as being effective for the throwing type of shoulder. Work done by a group of researchers<sup>8</sup> indicates that different types of athletes (in their study endurance athletes and high-intensity athletes like volleyball players and sprinters) respond differently to contract-relax and a technique called agonist contract-relax. The possible interaction between a specific PNF technique and a certain type of athlete is a situation that the athletic trainer in the field should be cognizant of and is a possible line of inquiry for the researcher.

## CONCLUSION

Proprioceptive neuromuscular facilitation techniques incorporate movement in the three planes of the body. With the current emphasis on multi-planar exercises in treating athletic injuries, PNF procedures provide an effective means for delivering this type of approach. Specific techniques for treating various injuries and areas of the body are provided in this study by athletic trainers who have successfully applied them to injured persons.

Rehabilitation of injuries has transcended strictly strength and range-of-motion development. While increments in these areas are important, neurological and neuromuscular enhancement are vital in contemporary rehabilitation protocols. Proprioceptive and kinesthetic deficits do accompany many types of injury. Data from this study indicate that athletic trainers are using PNF techniques in the re-education phase of injury treatment.

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